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CHINESE FISH CULTURE. HISTORY AND DEVELOPMENT,(U)
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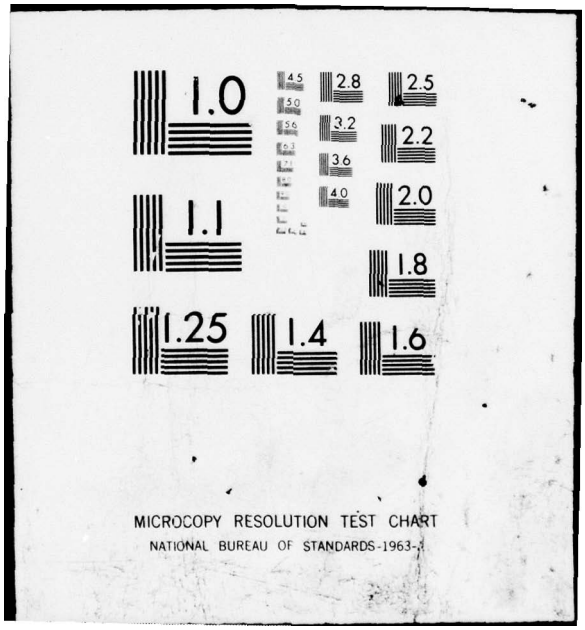
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Chinese freshwater fishery developed very early, through thousands of years of accumulated experience. Chinese archeologists, on the basis of fish fossils, consider that the earliest utilization of fish occured 15,000 to 50,000 years ago. Also, fish nets and other fishing gear, such as fish hooks, were used 5,000 to 10,000 years ago.

The earliest recorded utilization of fishery resources is from the Shan dynasty (1766-1122 B.C.).

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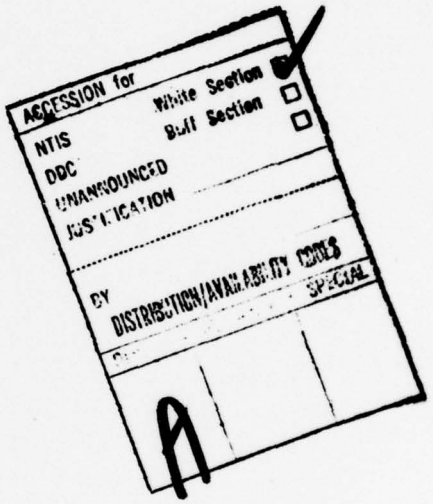
During the West Chou dynasty, which followed the Shan, opened and closed fishing periods were established, marking the beginning of resource conservation.

Pond fish culture was recorded in the Yin dynasty (1100 B.C.) with carp being the most likely fish cultured. Additional development in carp culture occured during the Han dynasty (206-221 A.D.), when culture was expanded into large surface areas and large sized fishing gear was used. Further improvements occured when mixed-species culturing, the process of raising common carp, grass carp and other cyprinids together, was introduced.



HISTORY AND DEVELOPMENT

Like agriculture, Chinese freshwater fishery developed very early, through thousands of years, by accumulated experience from actual practice. The valuable experience in fishery production was not recorded in the general literature and fishery subjects were not summarized or systematically analyzed, but were scattered as miscellaneous publications among ancient agriculture books, local gazettes, and biographical records.

The earliest author who worked on the history of Chinese fishery is Shen Tung-fong of the Ch'ing dynasty. His book, published in 1906, deals mainly with contemporary fishery matters. He mentions that Fan Li's Fish Culture Classic is a later publication discussing production. Finally, he points out that Chinese Classics such as "Erh Yiah," "Shih Ching," "Chou Kwan," "Li Chi" all contain some references on fishing tools and kinds of fish that contribute some material to Chinese fishery history. He makes citations from T'au Chu Kung's Four Books on Gardening concerning carp eggs and larvae, fish ponds and environment, and the various factors affecting fish pools. At the end, he cites from The Book on Agricultural Administration, (by Hsu Kwang Chi, the Ming dynasty, 1368-1644), fish culturing methods in Kiangsi and discusses fish pond system, mixed culture of two cyprinid species, fish food, and the utilization of sheep manure for fertilization purpose.

In 1940, there appeared an article on Pond fish culture in Hong-kong (Anonymous), in which it is mentioned that as long ago as Fu Hsi's time (2852 B.C.), people already wove nets to catch fish, and that during the reigning of Emperors Yau (2356 B.C.) and Shuan (2255 B.C.), there were special fishery administrators to oversee fishery matters. Not until the Ming dynasty (1368-1644 A.D.) when Hsu Kwang Chi published his The Book on Agricultural Administration, was there any mention of culturing of mixed cyprinid species. But, according to the anonymous author of that article, culturing of mixed species must have originated before the Ming dynasty, for Chou Mi of the Sung dynasty (960-1126 A.D.), in his Annual Memoirs, had already described the fish fry industry in the District of Kiang and the utilization of bamboo basket for fry transport. The same author surmises that mixed culture could have started in the Han dynasty (206-221 A.D.), basing his argument on Shihmah Ch'ie's Production Enumeration, in which Shihmah discusses "a thousand tons of fish live in the water."

Nee Dahsoo (1957) gives a brief historical account on Chinese fish culture in his article on "Methods on culturing Mylopharyngodon, Ctenopharynagodon, Hypophthalmichthys, and Aristichthys." First, he comments on Fan Li's Fish Culture Classic. Then, citing the fact that Emperor Ts'ou (85-75 B.C.) of the Han dynasty raised fish in Kuen Ming Pond, he considers that as evidence of expanding fish raising from small water mass to large water acreage. Also, in the years 605 to 617 A.D. in the Sui dynasty, records show that whitefish eggs from Lake T'ai were

hatched and raised in the imperial ponds, indicating that this was a prelude to large scale fish culture. Nee further points out that in the Tang dynasty (618-907 A.D.), people were required by law to liberate any carp they happened to catch, and those who were caught selling carp were fined. Undoubtedly this measure put a severe restriction on carp raising, and that must have led fishermen to explore for other species for culturing purpose. It is quite possible that the four other cyprinid species entered into the picture at that time.

Liu Tung Seng (1957), in his Historical Development and Present Condition of Chinese Fish Culture, lists The Book on Chou and Loew's Spring and Autumn Annals as evidence of the existence of conservation of fisheries resources by government regulation during the dynasties of Chou (1122-255 B.C.) and Ch'in (255-206 B.C.). He ventures the opinion that there were open and closed seasons in fishing, as deduced from several classical writings. In regard to the vicissitudes of carp culture, it is Liu's opinion that fish culture had become a prosperous venture during the Period Spring and Autumn Annals and the Period of Warring States (both in the later Chou dynasty). Carp raising, however, started to decline in the Tang dynasty. As a result, fisher men had to find other species to take the place of carp. It probably all started from following the ancient method of fish culture by introducing bottom material collected from rivers and lakes into fish ponds. As a result, other species of fish found their way into culturing ponds and were then utilized. The bighead and grass carp could have been discovered in this manner. Since the value to these fish and some other cyprinids

even surpasses that of the carp, they were a welcome addition to fish ponds by the fishermen. This, therefore, spelled further doom to carp raising. By the same token, fish raising had evolved from a single-species culture to a mixed-species culture, which represented quite an advance in technique.

It is evident from the references discussed above that although there is no publication that deals specifically with Chinese fishery history, a lot of historical material can be gathered from many classical writings. Naturally this kind of material is hardly sufficient for a complete review of Chinese fishery development through the ages. Also, some questions such as the exact beginning of rearing of the bighead, grass carp, and other cyprinids are yet to be answered. Much more research is therefore needed in order to clarify some of the unanswered questions.

Chinese Fish Fauna In Geological Periods

Among the fish fauna in the freshwater bodies in China, the cyprinids are by far the most abundant. Fossils of cyprinids discovered in China data back to the Miocene Epoch of the Tertiary Period. It is toward the last part of the Tertiary Period that the earliest man appeared. Several hundred thousand years ago, human beings inhabited the northwestern, northern, and southeastern parts of China. It is not unreasonable to imagine that fishes have been the hunting object of the humans ever since the Miocene time.

According to Young Tsung Chien and Hwang Wei Iung, Miocene fish fossils that were found in the District of Linchuen of Shangt Province included Barbus linchuensis Young and Tchang, B. scotti Young and Tchang, B. miocenicus Young and Tchang, and Pseudorasbor macroscephala Young and Tchang. Found in the district of Maoming of Kwangtung Province was Cyprinus maomingensis Liu. All five species of fish are now extinct.

From the Oligocene fish fossils, there were Matsya hsichili Liu, Barbus brevicephalus Chang, B.yunnanensis Regan, and B. szechuanensis Tchang: all from Plot no. 14 at Tsoukowtien. The last two species still exist today. In addition to the above there were found a gold-fish in the District of Taikou of Shansi Province and a related species in the District of Ch'uehching of Yunnan Province.

Fish species that were found in the Pliocene layers are all present today. The carp was discovered in Shiangfen District of Shansi Province and in Inner Mongolia; the grass carp was discovered in Shiangfen, Yuanshiang Township of Jiling Province, Plot no 3. of Tsoukowtien, the hilltop excavation at Tsoukowtien, and Pingloo District of Shansi Province. Mylopharyagodon, piceus was found in Shiangfen, Shansi, and the bighead carp (Hypophthalmichthys molitrix), in Pingloo, Shansi.

In the Quarternary layers were found Ctenopharyngodon, Mylorpharyngodon, Angstichthys, and Cyprinus. The former two were found in Yeetsong District of Hupei Province and in the vicinity of the Strait of the Three Gates of Honan Province. The latter two were found also in the last named locality.

A total of 15 species of fish fossils from the Miocene Epoch of the Tertiary Period to the Quarternary Period have been discovered at various localities in China. Undoubtedly the number of species will be greatly increased in the future following the development of vertebrate paleontology. Nevertheless, the total number of cyprinid fossils will be far less than cyprinid species now existing in those same areas. This is not necessarily because the ancient fish fauna was that poor, but because fossils always merely represent a fraction of what had been preserved. Further, many fossilized forms may never be discovered, and still others are so incomplete that they cannot be identified. For instance, some of the cyprinid fossils that were found in Shiang Village of Hunan Province and Pingloo District of Shansi Province from the Tertiary layers are yet to be identified to genus or species.

Judging from the distribution of fossil species in the Tertiary Period, it seems that some freshwater fish species, notably the Barbus group, were more widely distributed then than they are today. At the present, species of Barbus occur mostly south of the Yangt ze River: very few species are found in Northern China. In the Tertiary Period, they seemed to be widely distributed in the North, such as Shangtung and Pekiang.

Utilization and Processing of Fishes

Primitive man depended upon fish as one of his principal foods. This is evidenced by the artifacts of fish hooks and fish spears in the stone age. The discoveries of such artifacts in China are relatively

few, but plenty of fish bones were found in the Hilltop excavation at Tsoukowtien, indicating that man at that time did use fish as his food. A more revealing finding is that among these fish bones, there was one supraorbital bone which belonged to a grass carp and on which was some red paint and into which was bored a small hole. Fei Wen Chung, and archeologist, deduces that Peking man often fished in the lakes and ponds, took the fish as food, and utilized fish bones as ornaments.

After entering into the period of recorded history, reference on fishing and fish eating habits can be found in many classical writings.

Kuo Moa Yueh points out that of the inscriptions carved on turtle carapaces that were recovered from the Yin dynasty graves Lo Tseng Yueh collected a total of 1,169. Of these, 197 are concerned with fishing and hunting, of which 5 are related to fishing. These inscriptions are carved on the carapaces of turtles, usually for the purpose of fortune telling. When the carapace is baked from the underside, cracking lines will appear on the upperside, which are the basis for fortune telling.

The fish bones that were recovered from the Yin dynasty graves at Anyang District in Honan Province numbered 26 items. These are kitchen wastes of the families at that time. They included bones of vertebrae, hypopharyngeal, and opercle, and spines of pectoral fins, scales, and fin-rays. In addition, there was half of a skull in pretty good shape. From the characteristics of these bones, six species of fishes were identified: Mugil cwphalus, Pseudobagrus fulvidracs, Cyprinus carpios, Ctenopharyngodon idellus, Myplopharyngodon piceus, and Squaliobarbus

curriculus. To this last species belongs the half skull. Among these six species Mugil cephalus is a marine species. Its presence could be due to its upriver migration to Anyang. The remaining five species are all freshwater varieties. From this discovery, it can be assumed that these fishes were the common food species at that time and that they were obtained through fishing.

In Chinese classics, there are relatively few records of fish bones being used as ornaments or utensils. Shark skin has been recorded as ornamental, but shark is a marine fish. In freshwater species, bones of the Chinese black roach were known as being used as wine vessels and combs; and salmon skin used as hats, boots, and clothing.

There are more recordings in Chinese literature which indicates that fish had been used for medicinal purposes. Some species are said to be good for circulatory ailment, for building strong muscles, etc. The gall of the Chinese black roach is recorded as good for curing eye disease.

Processing of fish goes back to ancient times. Salting and drying are the most commonly used methods. Historical recordings of the usage of dried fish and possibly also of salted fish are quite numerous.

Another method of processing is the use of fish eggs in the making of sauce. Record has it that people of Yah District especially esteemed the roe of sturgeon. The roe is marinated in salt and eaten raw. It is evident that the Chinese people have long utilized sturgeon roe and the method of processing is much the same as is practiced by the Russians.

Fish smoking is also recorded in early Chinese history. The method of smoking is much the same as it is practiced today.

Now a word about the transportation of live fish. In the big cities of eastern China and Canton, freshwater fishes are sold alive. Mostly, live fish are transported via "live water boat." In the U.S.S.R., sturgeon and catfishes are transported in similar manner.

Fishing Gear and Fishing Methods.

In Europe, there are many old stone age discoveries of fishing gear used by primitive man. No such discoveries have been made in China so far. In the new stone age, relics have been found in China quite often. These are in the form of bone-made fish spears and hooks.

During the Shang dynasty (1766-1122 B.C.), although agriculture had already been developed, hunting and fishing still accounted for a good part of production. This is also the brass era. Brass fish hooks were discovered among the Shang relics in Honan Province. The utilization of iron and steel in making fishing tools occurred in Chou dynasty (1122-221 B.C.) or thereafter.

We cannot find literature that deals with the transition from a single hook to hook and line and multiple hooks. Aside from the hook, there is the line, float, and bamboo pole. In old China, fishing lines are made of hemp or silk. Only in modern times, do people utilize silk produced from wild silkworm. This wild silkworm matures in May and drops down from a tree by hanging to its own silk. People remove its

silk glands and soak them in vinegar and immediately pull them into long filaments, which become the silk fishing line. This kind of silk fishing line is produced in Hunan and Fukien, and was at one time exported to Japan in large quantities.

Net is the most important fishing gear; it is the most advanced gear among the primitive gears. In Shangtung and Shensi Provinces, stone weights were discovered in the new stone age relics. In Fukien and many other places, fishing weights made of porcelian material were found.

Nets became more and more complex as time went on. Many bagged nets and tow nets are known to have existed as long ago as Chou and Han dynasties.

In the following are described some of the fishing methods that are recorded in Chinese classics.

(1) Artificial wood nest. This is the method most commonly used in large and medium sized lakes in Hopeh Province. It involves placing twigs, logs, etc. in the water under which fish gather and are subject to harvest.

This method relies on the habitat of fish. If fish of all sizes are caught, it is a harmful practice; on the other hand, if care is taken in taking only the large fish, then it becomes an efficient method. This is especially useful in shallow lakes and ponds along the Yangtze River, where predacious fish species are dominant.

(2) Fishing with otter. In rapids where there are boulders and rocks, the utilization of otter to fish or to chase fish is a very efficient method. To domesticate otter for fishing purposes is a common practice in Europe, but is more prevalent in Asia. In history, it is the earliest developed in China. The earliest European record of using tamed otter to catch fish is in Vincent de Beauvais' Things in Natural World (1480). In Asia, aside from China, otter is also used in India and Malaysia, but does not date back too early.

In a Chinese classic in Liang dynasty (502-566 A.D.), otter was mentioned but no mention was made of using it to fish. A definite record of using tamed otter to fish occurred during 806-820 A.D. during Tang dynasty. Even today otter are still used by some Chinese fishermen but only one otter is used on each boat, and the method of fishing is also different from ancient time.

The recording of Chinese use of the otter to fish is also seen in foreign literature. Gudger, an American ichthyologist, describes otter fishing in detail.

(3) Fishing with comorant. In China, raising comorant to fish dates back to Tang dynasty. Tu Pu, the great poet, writes (between 759-768 A.D.) about comorant fishing in Szechuan Province. Since then more writings about comorant fishing occurred in Sung and Ming dynasties. Generally speaking the method of fishing has not changed much since the early times.

Gudger also published an article about comorant fishing in China. He cites from Frior Odoric, who traveled in China during 1323-1328. He

also considers the opinion of Haufer, who thought comorant fishing started in China in Sung dynasty (960-1298 A.D.), and that it started in Japan even earlier - about the 6th century.

Comorant fishing is useful in rapids where the bottom is covered with rocks and boulders, and where it is difficult to set a net.

(4) The use of light to attract fish. In the Soviet Union today, electric light is utilized to fish. By using different colored lights and different intensities of light, various species of fish are attracted to the light and caught. This is, of course, a modern device. The Chinese people have for a long time utilized the same principle in fresh-water fishing, although using a much simpler method. In the various tributaries of the West River, for instance, where the water is very clear, fishermen often fished during the night by lighting a torch at the bow of the boat. After the fish had gathered under the light, fishermen would set the net.

One classic records: "In the East Sea, fishermen do not use nets. Two fishermen go out in a small craft at night placing a lighted lamp in the boat. Fish (species undetermined), upon seeing the light, leap into the boat filling the boat in no time. The light has to be put out, or it will become overloaded." In Sui-Ang, Chekiang, fishermen use a special method to catch minnow. They affix a long white painted board on the side of a small boat, immersing half of the board into the water and at the same time causing the boat to tip slightly toward the side. They often do this at a fairly good speed on a moonlit night in a river.

Minnows leap into the boat along the white board. This kind of fish method is based on the leaping habit of the minnow on the one hand, and on the white attraction principle on the other.

In "Ancient and Modern Secrets," which was published in the late 18th century, one paragraph goes: "In a summer night, get a goat bladder as soft as paper and blow it into a balloon. Fill it with a hundred and more fireflies, tie the mouth, and affix it to the bottom of a lift net. Many fish, large or small, will race for the light and aggregate there quietly for the easy lift. Though simple, this method is an ingenious one. Unfortunately, it has not been developed further.

Conservation of Fisheries Resource

The utilization of fisheries resource in natural water bodies dates back to primitive man. In the old days, due to a small population density and therefore low demand, the poor efficiency of fishing gear, the catches were small. Following historical development, the utilization surpassed that of natural reproduction and fisheries resources were depleted. Thus, conservation problems began attracting attention and conservation measures were instituted.

In Europe, conservation laws on aquatic resources were first recorded in the 5th century. In China, some fishing laws were initiated during the West Chou Dynasty, 1122 B.C.

In the "Chou Ceremonials," it is mentioned that the government set up special fishery officers of various ranks who oversaw government regulations and the fishermen who did the catching. At that time, there were five fishing periods: 1. early spring, 2. spring, 3. autumn, 4. the 10th moon, 5. winter. It follows that fishing was not allowed in the summer, because summer is the spawning season of many fishes. The prohibition of fishing activity during the spawning season is also recorded in later classics.

Aside from the above regulations, other conservation ideas were also evident from Chinese literature. Authors in Han and Wei dynasties (206-265 A.D.) often mention that small fish are not to be kept or sold.

During the Ming and Ching dynasties (1368-1911 A.D.), there were laws prohibiting the catch of spawning fish, and fishing on spawning ground.

Freshwater Fish Culture

Chinese classics concerning pond fish culture are fairly ample. It is quite possible that pond culture started during the Ying dynasty (before 1122 B.C.). From that time till the Tang dynasty (590 A.D.), the main topic was carp culture. It is during the late Tang period (early 900's A.D.) that articles concerning the grass carp, the black Chinese roach, and the bigheads appeared. During the three succeeding dynasties (Sung, Yuan, and Ming) this kind of literature greatly increased and also was in much greater detail.

Pond culture started around 1142 B.C. This is based on "Poem Classics." From early Chou till the Warring States, 700 years had elapsed, during which period numerous references were available in which pond culture ventures were mentioned.

From Fan Li's Fish Culture Classic. Published about 460 B.C. it is apparent that culturing of carp was a common practice. This book not only promoted the development of fish culture in China after the Warring States (403-221 B.C.), but also was a major influence on carp raising in European countries. There is no doubt that carp was transplanted from China to Europe and with it the fish culturing method.

Judging from the contents of Fan Li's Fish Culture Classic, it is clear that experience in raising carp was already ample by that time. Especially worth mentioning are the following seven points:

First, in a one-acre pond, nine islands are built in order to provide resting places along the shores for the carp and to make the fish feel that it is not in a vast lake. Such a device would probably adversely affect harvesting efficiency but on the other hand, it would offer the carp a desirable environment.

Second, eight "valleys" are constructed in the pond. These valleys are either shallow (2 feet) or deep (6 feet). The same is used for raising both young and adult. It is therefore essentially that both shallow and deep waters are provided. Deep waters are less affected by extreme temperatures, and are therefore a good hiding place for the fish. During the spawning season, young fish activity is mostly confined to the shallow part of the pond.

Third, the major species reared in the pond is the carp, which is capable of spawning naturally in the pond. It is reasonable to assume that at first a number of naturally occurring species are caught and put in the pond. Many species would neither live nor breed. Only the carp becomes adapted to the pond culture.

Fourth, for stocking, 20 females and 4 males, each measuring about two feet in length, (about 8 pounds) are placed in the pond. This 5: 1 female: male ratio is a reasonable one, consider the fact that the females will not all mature simultaneously and that sperm are continuously produced by the males during the breeding season.

Sixth, the first harvest can be taken one year after introduction. Some of the fish measuring 1, 2, and 3 feet long can be taken. The second year, fish measuring 1, 2, 3, and 4 feet are gathered. At the same time, 2000 fish measuring 2 feet in length are placed in the pond, and therefore, cultured in mixed sizes. Since food for large and small carp varies, raising mixed sizes can better utilize natural food than raising purely large or purely small fish.

Seventh, the book drives hard at the profit angle in pond culture.

Fish culturing business continued to develop and expand from the period of Warring States through Chin dynasty to Han dynasty. It is during the Han dynasty that large area culture had its start. Area expansion posed no problem to carp culture, and therefore it was only natural that rearing areas increased. Several references can be found in Chinese classics telling of the use of reservoirs and lakes to raise a large number of fish, the major cultured species was the carp.

From the Han to Tang dynasties, a period some 370 years, there was little further development in freshwater fish culture, because of many civil wars and the unsettling social conditions. During the reig n of Tang emperors, however, fish culture suffered a tremendous setback. The reason for it is rather amusing. The first emperor of Tang carried the family name of Li, which is read with exactly the same sound as that for the carp. Carp therefore became symbolic for the royal family, and it followed that the common name of carp became "red king." Those who caught carp had to release them, and those who marketed carp were punished by 60 spankings. These rules were written into law. Consequently, since nobody was allowed to eat or sell carp, carp raising was dealt a severe blow. It is therefore not difficult to understand why people turned to culturing other species.

To rear grass carp and other related cyprinids, it is necessary to obtain fish fry from the river and place the fry in the pond to grow. In this respect it differs from carp raising. Therefore, quite a transitional stage must have occurred in the change from carp raising to grass carp raising. It probably started with people who lived by the river--especially the Yangtze and Pearl Rivers; presumably they caught some of the fish fry discovered along the river band and transferred them into a pond. The fry of 20 to 30 fish species could occur along the river bank, but of course, not all species transferred to ponds would have survived. Through long experience, the grass carp, black Chinese roach, striped bighead, and white bighead, were identified and selected.

The Tang dynasty lasted from 618 to 904 A.D. In these 286 years, freshwater fish culture underwent a dramatic change, and by the end of the Tang era, the culture of the four "domestic cyprinids" was well established.

From Chou Mi's Miscellaneous Writings, published about 1243, it is known that people in KiuKiang collected tiny fish fry from the river, transported them, treated them for half a month for a month and marketed them. It was known then that these fish, when reared to adult stage, would not breed.

In Chekiang's official documents, which cite publications of 1201-1204, it is stated that fish culture in that province started during the Sung dynasty. Farmers bought their fish fry from Kiukiang fishermen, and continually raised both fry and adults mixed. Also, species were mixed in the culture. They consisted for the four domestic species: grass carp, black Chinese roach, striped bighead, and white bighead. It is quite certain that during the Sung dynasty, people already had some accurate knowledge about the feeding habits of these domestic fishes.

From the Southern Sung to the end of Ming, 300 to 400 years elapsed and during this period there was significant development in freshwater fish culture, as is evident from two important references: Huang Sen Tseng's Fish Culture Classic, and Hsu Kwang Chi's The Complete Book on Agricultural Administration. In the latter, a section is devoted to fish culturing methods in Kiangsi Province.

Huang Sen Tseng's publication summarizes contemporary fish rearing experience and shows tremendous improvement in the rearing of grass carp, black Chinese roach, white bighead, and striped bighead. Of special interest is the material regarding the construction of fish ponds, the care of pond environment, and some causes of fish kills in the pond.

Hsu Kwang Chi's work is composed of 60 volumes dealing with various facets of agriculture; fish is included only in the chapter on animal husbandry. The description of fish fry collection, morphology, and feeding habits of domestic fishes is similar to that of Huang. Also similar is the section on culturing methods. Hsu also describes methods of curing fish that have contacted poison and summarizes fish culturing methods in Kiangsi Province.

Much of the technique memtioned in Hsu's book had not been recorded in previous literature; some methods are still being adopted today. The following points are worthy of discussion.

1. Construction of fish pond. Ponds are classified into three sizes, for rearing different sizes of fish. Bighead and grass carp that are about one inch in length are reared in small ponds (10 feet square); larger fish taken out of fry rearing ponds are reared in medium-sized ponds (20-30 feet square); fish weighing over a pound are raised in large ponds (120-180 feet square).

In the center of the small pond another pond is excavated, measuring 5 feet square and 2 feet deep. The latter pond-within-a-pond is used, at first, to rear young fry, then as the fry grow larger, the entire pond is filled up gradually to provide deeper water and larger surface area.

In winter, the pond is drained and the mud removed, thus removing excessing organic matter on the bottom and providing an opportunity for pond repairs. Such a practice is still being used today in Kiangsu and Chekiang provinces.

2. Species mix. In the small pond are reared 200 of grass carp and 600 bighead. Obviously, the 3 bighead, 1 grass carp ratio which is followed today has a traditional background.

3. Fry density. In the 10-feet square pond, 800 of small fry can be raised; in the 20-30 feet square pond, 700-800 larger fingerlizings can be raised. The number of fish per unit area is reduced following the fish's growth.

4. Feeding. This is discussed in much detail and many good points are made. To raise small fry in the small pond, the pond should be filled with water during the spring festival (early April) before stocking, in order to allow plankton to multiply. After stocking, grass carp should be fed with aquatic plants daily. Excreta from grass carp function as a fertilizer to promote plankton growth, thereby increasing the food for the white bighead. When aquatic plants are not available, egg shells and mud are used instead; the latter increase the calcium content of the water, thus promoting the growth of fish.

For medium-sized ponds, aquatic weeds should be planted during late March and early April, and stocking should not be done until after the first of June. It is recommended that the carp feed on the naturally grown weeds first, and after the vegetation is finished, leaves and stems of aquatic plants be added into the pond.

For large ponds, whole weed or jute leaves can be used as feed.

In winter, when fresh vegetation is lacking, a special preparation of hay is used. This feed is made be adding urine to hay, storing this for several days, chopping it into fine pieces and making it on balls with mud. After drying, the balls are ready for use.

5. Pond changing. Fry about one inch in length are stocked in small ponds in early spring; they are transferred to medium-sized ponds in early June; when they weigh over one pound, they are further transferred to large ponds. Finally they are harvested in the fall, when they weigh around four pounds.

6. Fish diseases. Hsu is one of the earlier writers to touch upon fish diseases. He not only gives an accurate description of the external morphology of fish fleas, but also mentioned methods of control.

7. Records of culturing of grass carp, black Chinese roach, white bighead, and striped bighead in Ching Dynasty. Two publications relating to fish culture from the Ching dynasty stand out. One, by Chueh Ta Tchuen, titled "New Contributions from Kwangtung," was published around 1700 A.D. One of its features is a method of segregating species in a mixed container. It maintains that different species of fish fry will stratify themselves in a container. The stratification becomes more evident as dissolved oxygen gets lower and more sensitive species come to the surface gulping. Fish removed from the surface layer consist mainly of white bighead, striped bighead, and some wild fry. A few black Chinese roach may also be present. Those removed from mid-layer are mainly grass carp, mixed with a small number of bigheads. Those removed from the bottom layer belong mainly to Cirrhina molitorella.

In Chekiang province fishermen intentionally let dissolved oxygen decrease to such a level as to kill off wild fry.

The other major publication is by Kopseh (1876) on "Fish Culture in Kiangsi," in which the author describes the method of collection, transportation, and morphological characteristics of fish fry.

Origin of fish rearing in rice fields. In China, raising fish in rice fields is most prevalent in Szechuan, Kwangtung, and Hunan. There is no definite record as to when rice field fish culturing started. Two historic records indicate, however, that during the period of the Three Kingdoms (22 A.D.), and a somewhat later period (Chi dynasty), carp and grass carp, respectively, were harvested out of rice fields.

Origin of fish culturing in rivers. The utilization of rivers for fish culturing is best known in Chekiang Province. It is quite likely that river culture did not start until after 1537, when the dam and water gate were completed on the Chiantang River. Fishermen use bamboo screens to block off the rivers, thereby providing large areas for fish culture. This kind of culture differs from pond culture in that no added food is necessary. The fish grow entirely on natural food. Gates are also constructed for the sake of navigation.

Summary

To summarize some of the more important developments in freshwater fisheries in Chinese history, we have discovered fossils of 15 cyprinid species. Ten species are still present today, such as the carp, goldfish, grass carp, black Chinese roach, white bighead, striped bighead, etc.

Chinese archeologists, on the basis of fossil findings of fish bones, consider that the earliest utilization of fish by man occurred 15,000 to 50,000 years ago.

Many single fishing gears, such as fish hooks, forks, bladder, etc. that belong to the neolithic period have been discovered in many places in China. These were all made of animal bones, 5,000 to 10,000 years ago. During the same period, fishing nets were used, for stone and pottery sinkers were present.

After the prehistoric period, the utilization of fishery resources is recorded in literature. The earliest record is from the Shan dynasty, 1766-1122 B.C. Fishing hooks made of brass were found during the period.

During the West Chou dynasty, which followed the Shan, special government official positions were set up for the sole duty of fishing. Open and closed fishing periods were established. This marks the beginning of resources conservation.

The earliest record of pond fish culture is found in the late Yin dynasty (about 1100 B.C.). Carp was most likely the species cultured. Pond carp culture was quite common during the Warring States, 403-221 B.C.

Further development in carp culture occurred in Han dynasty (206-221 A.D.), when culture was expanded into large surface areas. Large size fishing gear was also developed.

Carp raising in rice fields had its inception during the Three Kingdoms (221-265 A.D). Transporting live fish originated in the period of 420-589 A.D.

During the Tang dynasty (589-960 A.D.), carp was proclaimed a sacred species and carp raising was heavily suppressed. As a result, grass carp, black Chinese roach, white bighead, and striped bighead became culture objects. At the same time, otter and cormorants were being utilized to fish for man.

Continued progess was made on all aspects of freshwater fish culture from the Tang dynasty through the Ming and Ching dynasties. Especially rapid advances have been made during the last ten years. Yields from pond culture have been increased ten-fold. China stands now at the forefront among the world's nations in freshwater fish culture.